Comparative Analysis of Inventory Optimisation Algorithms

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Abstract
The article considers the statistics of sales of wristwatches of various types and the actual stock of these products in a specialised store. To determine the optimal number of stocks of these goods, the ABC-XYZ inventory method, regression analysis and the method of optimisation through modelling the cumulative consumption were used. It is proved that actual records can be reduced by an average of 20%. The advantage of the statistical optimisation method is shown as the fastest and easiest to use.

1. Introduction

The relevance of comprehensive optimal inventory planning in the warehouses of a trading company is driven by several important aspects related to the efficiency of the company's management, ensuring its competitiveness and sustainability in a changing market environment. Optimal inventory planning can significantly reduce the cost of storing goods by minimising excess stock that takes up precious warehouse space and requires maintenance costs. It also avoids losses due to spoilage or obsolescence, reducing the need for constant purchases of 'stock'.

Effective inventory management ensures optimal turnover of goods, which reduces the need for working capital, facilitates rapid turnover of goods and frees up funds for other investments or operational needs. Inventory optimisation helps to ensure timely and accurate fulfilment of customer orders, reducing the likelihood of stock-outs.

Modern technologies, such as automated inventory management systems, artificial intelligence, machine learning and big data analytics, improve the accuracy of demand forecasting and inventory optimisation, making the management process more efficient and cost-effective. Carefully planned inventories help reduce the risks associated with fluctuations in demand or supply disruptions, ensuring the stability and reliability of a retailer's operations.

A comprehensive approach to inventory management can include scenario-based planning, which allows you to consider possible negative impacts and prepare response strategies. The ability to optimally manage inventory is an important factor in increasing competitiveness. With the right strategy in place, a company can offer competitive prices, faster delivery of goods and better quality of service, which gives it an advantage in the market.

As a result, comprehensive, optimal inventory planning is an essential tool for the efficient and sustainable operation of retailers, which not only reduces costs but also improves customer service and adapts to changing market conditions.

2. Materials and methods

The methodological basis of the work is the general laws of scientific knowledge, fundamental provisions of theory and regulatory documents and resolutions.

The methodology of this work is also based on general and special methods of scientific knowledge. Formal and logical methods were used in the formation of key concepts and definitions of the work, their implementation in the economic aspect. Also, in the course of the study, various general scientific and special methods of cognition of economic phenomena and processes were used. Among them are: generalisation, comparison, induction and deduction, systematisation - when studying the concepts of 'reserves' and 'planning' and their components; generalisation and system analysis - to draw conclusions. A dialectical approach to the study of the state of accounting in Ukraine will also be used, the method of induction - at the stage of collecting, systematising and processing information for the study, deduction - in the process of theoretical understanding of the problem, analysis and synthesis - to combine various components of economic phenomena in a single process.

The ABC-XYZ inventory method, regression analysis, ETM analysis, and the method of optimisation through consumption cumulative modelling were used to determine the optimal stock levels for these goods. All calculations were carried out using Microsoft Excel in the Data Analysis and Solver advanced modes.

The actual data was taken from the open financial report of Decada LLC for 2021-2024 and with the permission of the company's management. The problem of the LLC is uncertainty in the stock of unsold goods, which will reduce the turnover of equity.

3. Results

3.1. ABC XYZ analysis

The ABC/XYZ analysis of goods is used to rank the goods used to prepare items by importance to the result (ABC) and stability of the result (XYZ). The analysis is based on sales volume, sales value and sales change ratio.

The list of product numbers ranked according to the ABC XYZ method is presented in the form of a matrix with a description of each category. The inventory allocation matrix is shown in Table 1.

Thus, we can say that the commodity groups have been divided into valuation categories and are subject to further analysis.

Table 1: ABC-XYZ matrix for Decada LLC

	X	Y	Z
A	Smart watches for men; Smart watches for women; Mechanical watches for men; Smart watches for unisex; Quartz watches for women;	Quartz watches for men;	
B	Механічні годинники жіночі	Men's watches; Unisex watches	Luxury watches; Accessories; Unisex quartz watches;
C	Self-winding women's watches; Unisex mechanical watches;	Jewellery	Sets

The purpose of ABC analysis is to select the most attractive product categories for sale, which are not very expensive or large in quantity, but bring the maximum effect. The financial and economic model of this paper is based on cost indicators, so we will define the profitability of each product category of inventory as a valuation indicator through the coefficient expression of the valuation. This is important because this method of calculation is weighted, expressed in relative terms, and covers a large number of financial indicators.

Therefore, we build the indicator for ABC analysis on six indicators of the ABC component. The formula for calculating the indicator was compiled by the authors using the geometric mean method. Six indicators from Table 3.3 (from K1 to K6) were selected for calculation. The resultant indicator P1 (ABC component) is calculated using the geometric mean formula:

$$1 = \sqrt[6]{К1 * (\frac{1}{К2}) * К3 * (\frac{1}{К4}) * К5 * К6}$$

Where:

P1 - indicator for assessing the effectiveness of inventory sales;

K1, ...K6 - detailed indicators for assessing inventory.

Indicators K2 and K4 in the formula are taken in the inverse definition because they are the stimulus indicators for the effective value. The other indicators (K1, K3, K5, K6) are taken into account by their direct value. After determining the P1 indicator, the ABC analysis is performed using the algorithm adopted for it. Table 2 shows the work of the ABC analysis algorithm on the example of the data of the analysed enterprise.

Thus, based on the results of the table, we can conclude that the range of inventories is fairly distributed among the categories of goods. Category A includes inventories that account for up to 75% of the result. At the same time, it has lower costs compared to other categories. Therefore, the following should be included in the strategically important group of inventories: smart watches for women, smart watches for men, unisex smart watches, quartz watches for men, quartz watches for women, mechanical watches for men.

Category B requires less attention, but also generates a fairly high return - up to 20% of the result, and therefore the loss of this category can lead to a loss of profitability. Category B includes inventories of men's self-winding watches, luxury watches, accessories, unisex quartz watches, unisex self-winding watches, and women's mechanical watches. Inventories from the categories of unisex mechanical watches, women's self-winding watches, sets, jewellery do not need to be planned in detail.

Table 2: Results of the ABC analysis of the inventory of Decada LLC for 2024

№ p/n	Name of inventory Indicator	P1 Indicator	PV Specific	Gravity of P1, %	Accumulated specific gravity, %	Category
1	Smart watches for women	2,93	0,51	18,42%	18,42%	A
5	Smart watches for men	2,89	0,35	18,16%	36,58%	A
9	Smart watches for unisex	1,87	0,43	11,75%	48,33%	A
6	Quartz watches for men	1,76	0,38	11,06%	59,40%	A
2	Quartz watches for women	1,41	0,47	8,86%	68,26%	A
7	Mechanical watches for men	1,07	0,68	6,73%	74,98%	A
8	Automatic watches for men	0,68	0,29	4,27%	79,26%	B
13	Luxury watches	0,55	0,25	3,46%	82,72%	B
16	Accessories	0,48	0,7	3,02%	85,73%	B
10	Quartz watches for unisex	0,43	0,52	2,70%	88,43%	B
12	Automatic watches for unisex	0,42	0,53	2,64%	91,07%	B
3	Mechanical watches for women	0,34	0,64	2,14%	93,21%	B
11	Mechanical watches for unisex	0,34	0,66	2,14%	95,35%	C
4	Automatic watches for women	0,28	0,58	1,76%	97,11%	C
15	Sets	0,27	0,32	1,70%	98,81%	C
14	Jewellery	0,19	0,65	1,19%	100,00%	C

3.2. Regression analysis

As the resultant indicator of the multiple regression model, the revenue from the sale of inventories (V) is taken, which varies depending on the list of variables: inventory turnover ratio (K6); inventory liquidity ratio (K7); inventory growth rate (from the natural value) (K8); inventory consolidation ratio (K9); inventory shortage ratio (per month) (K10); inventory release rate due to accelerated turnover (K11).

Regression analysis was performed using the Regression Excel spreadsheet application.

Table 3 presents the statistical characteristics of the regression analysis for each type of OOI separately. These values characterise the statistical reliability of the approximation and can be used for further analysis.

Table 3: Results of ABC-analysis of inventories of Decada LLC for 2024

Commodity	R-squared	t-statistic	P-value	F-criterion	Significance F
Luxury watches	0,5864	1,191	0,445	1,418	0,445
Accessories	0,5865	1,191	0,445	1,418	0,445
Sets	0,2543	0,584	0,664	0,341	0,664
Unisex mechanical watches	0,9997	69,567	0,009	4 839,621	0,009
Smart watches for women	0,9998	79,176	0,008	6 268,807	0,008
Smart watches for men	0,9999	98,814	0,006	9 764,159	0,006
Mechanical watches for women	0,9934	12,305	0,052	151,413	0,052
Automatic watches for women	0,9991	34,230	0,019	1 171,667	0,019
Smart watches for men	0,9992	36,189	0,018	1 309,618	0,018
Quartz watches for women	0,9934	12,305	0,052	151,413	0,052
Unisex self-winding watches	0,8725	2,616	0,232	6,844	0,232
Jewellery	0,6285	1,839	0,207	3,383	0,207
Quartz watches for men	0,8369	5,452	0,032	29,720	0,032
Mechanical watches for men	0,9988	40,887	0,001	1 671,776	0,001
Quartz watches for men	0,566	1,616	0,247	2,612	0,04
Self-winding watches for men	0,8189	3,008	0,095	9,049	0,03

The results of the calculation of the XYZ analysis of Decada LLC based on variable indicators are presented in Table 4. Now, thanks to the regression analysis, it is possible to distinguish three categories of variations in inventory by individual categories.

Table 4: Results of the XYZ analysis of Decada LLC based on the 2024 valuation indicators.

№ p/n	Inventory name	Indicator R	Category
1	Luxury watches	0,5864	Z
2	Accessories	0,5865	Z
3	Sets	0,2543	Z
4	Mechanical watches unisex	0,9997	X
5	Smart watches unisex	0,9998	X
6	Smart watches unisex	0,9999	X
7	Mechanical watches unisex	0,9934	X
8	Automatic watches unisex	0,9991	X
9	Smart watches unisex	0,9992	X
10	Quartz watches unisex	0,9934	X
11	Automatic watches unisex	0,8725	Y
12	Jewellery	0,6285	Y

13	Quartz watches unisex	0,8369	Y
14	Mechanical watches unisex	0,9988	X
15	Quartz watches unisex	0,566	Z
16	Automatic watches unisex	0,8189	Y

3.3. Statistical analysis

Let's analyse the dynamics of inventory consumption for one month, the results of this statistical study are presented in Table 5.

Table 5: Current inventory requirements for Decada LLC

Day of the month number	Luxury watches Accessories	Accessories	Sets	Mechanical watches unison	Smart watches unison	Smart watches unison	Mechanical watches unison	Automatic watches unison	Smart watches unison	Quartz watches unison	Automatic watches unison	Jewellery	Quartz watches unison	Mechanical watches unison	Quartz watches unison	Automatic watches unisex
1	14	21	15	37	83	30	26	37	10	18	34	6	13	28	6	8
2	17	2	1	65	65	41	6	50	40	25	25	9	68	38	52	51
3	15	10	16	50	34	131	27	18	31	28	15	6	29	29	25	14
4	16	22	6	74	36	33	29	41	33	30	37	16	31	11	27	142
5	20	24	8	28	46	43	37	52	17	23	47	8	16	39	3	54
6	2	34	8	66	45	22	36	21	73	37	26	4	29	29	33	52
7	18	3	15	85	24	41	35	50	40	36	45	7	38	38	12	51
8	20	24	8	68	46	43	37	52	16	37	47	19	39	39	31	54
9	21	5	9	73	50	46	40	56	45	79	70	8	42	66	33	4
10	22	10	6	18	29	99	23	97	32	26	34	6	28	28	22	38
11	33	9	6	45	27	28	22	34	18	87	32	2	26	26	20	35
12	29	15	22	91	36	19	44	49	40	36	14	8	42	12	52	56
13	25	22	6	55	28	30	34	38	31	28	34	5	33	33	5	44
14	4	14	3	58	30	32	76	40	23	29	37	7	35	38	26	47
15	5	15	2	74	38	41	46	51	42	28	17	3	44	44	15	59
16	22	5	8	83	49	4	45	54	41	39	48	9	87	43	33	58
17	20	3	8	71	48	75	44	95	22	38	66	8	36	42	32	156
18	11	15	9	74	77	46	46	56	42	36	49	9	42	23	46	5
19	3	25	9	80	54	49	50	60	45	6	152	2	27	47	22	63
20	17	2	17	58	40	6	36	44	33	28	38	7	35	35	20	4
21	28	14	4	84	36	10	44	50	42	33	46	19	43	43	26	58
22	11	15	8	71	49	44	13	14	41	34	17	8	42	42	25	23
23	20	4	8	69	48	43	42	52	80	29	46	8	41	41	15	55
24	32	25	4	33	20	5	44	55	42	25	49	9	63	43	5	58
25	3	26	9	78	54	48	47	109	45	38	52	2	46	46	17	62
26	6	2	6	56	38	34	44	42	32	27	23	7	12	33	29	44
27	23	6	8	69	48	43	72	12	74	34	76	8	41	71	24	55
28	26	11	3	74	17	12	33	41	31	26	56	2	32	32	9	41
29	8	13	12	97	40	15	35	43	13	24	38	7	34	34	29	4
30	1	15	9	73	65	45	4	15	87	65	19	9	53	13	26	58

Based on these statistics, cumulative consumption was calculated.

4. Discussion

To determine the optimal stock of goods using the ABC-XYZ method, let's look at Table 4. The ABC-XYZ matrix for Decada LLC shows the distribution of goods by category. We choose a management strategy for each category and compare the result with the results before the changes were implemented. The results of this analysis are shown in Table 6.

Table 6: The proposed new volume of inventory for Decada LLC

Inventory category	Strategy to change	New inventory strategy	Inventory savings as a percentage of inventory	Share in inventory, weight
Smart watches for men; Smart watches for women; Mechanical watches for men; Smart watches for unisex; Quartz watches for women; Self-winding watches for men	Have a standard stock of goods - half the turnover for the period	To have a stock close to the level of consumption, without excessive accumulation, with a 30 per cent reserve	Up to 20% of the inventory	0,5
Mechanical watches for women	Have a standard stock of goods - half the turnover for the period	To have a stock close to the level of consumption, without excessive accumulation, with a 20 per cent reserve	Up to 30% of the inventory	0,2
Self-winding women's watches; Unisex mechanical watches;	Have a standard stock of goods - half the turnover for the period	To have a stock close to the level of consumption, without excessive accumulation, with a 10 per cent reserve	Up to 40% of the inventory	0,15
Quartz watches for men	Have a standard stock of goods - half the turnover for the period	Have a stock with a 60 per cent margin	An additional 10% of the inventory	0,05
Luxury watches; Accessories;	Have a standard stock of goods - half the turnover	Have a stock with a 60 per cent margin	An additional 10% of the inventory	0,05

Unisex quartz watches;	for the period			
Jewellery, sets	Have a standard stock of goods - half the turnover for the period	Do not change	0%	0,05

So, in general, the savings on inventory will be = 20% * 0.5 + 30% * 0.2 + 40% * 0.15 + 10% * 0.05 + 0% * 0.05 = 10 + 6 + 6 + 0.5 = 26.5%
Using this data, you can calculate the savings by reducing the volume of inventory. Let's calculate the figures for each category of inventory.
Current inventory costs: ordering costs, unit storage costs. So, before the inventory savings were made, we had the following cost data: Demand per month (D): 12,000 watches; Cost per order (S): 400 UAH.
Storage cost per watch per month (H): 60 UAH
Previously, orders were placed in batches of: 1,200 watches.

1. Calculate the optimal batch using the Wilson's formula (EOQ):

EOQ=√2×D×S/H

EOQ=√2×D×S/H

EOQ=√2×12 000×40060=√160 000=400 hours.

Optimal order size: 400 hours.
Without optimisation (and before the strategy is implemented), the number of orders per month:
12 000: 1200= 10 orders.
Cost per order: 10×400=4,000 UAH.
Average stock: 1200: 2=600 hours.
Costs of storing the stock: 600×60=36,000 UAH.
Total costs (before strategy implementation) for the month: 4,000+36,000=40,000 UAH.
According to the Wilson model (optimisation). Number of orders per month: 12 000:400=30 orders. Costs per order: 30×400=12,000 UAH.
Average inventory (taking into account 26% savings):

400:2*(1-0.26)*60 = 8880 UAH.

Storage costs: 12 000 + 8880 = 20880 UAH per month. So, we will have a monthly saving on inventory in the amount of: 40 000 - 20880 = 19120 UAH per month.
To determine the optimal stock by the statistical method, it is necessary to describe the cumulates compiled according to Table 5 with formulas such as

$$F(x) = a\text{Ln}(x) + b, \quad (1)$$

Where a, b – coefficients, x – quantity of goods consumed.
Next, for each type of product, it is necessary to find k1 - the unit cost of the product plus additional storage costs; k2 - the profit from the sale of a unit of product.
These values allow us to find the potential cumulative value for each type of product as

$$F_{opt} = \frac{k_2}{k_1+k_2}. \quad (2)$$

Substituting (2) into (1) and solving this formula with respect to x, we find the optimal stock for each product as

$$x_{opt} = EXP\left(\frac{F_{opt}-b}{a}\right).$$

After performing the relevant calculations, we will get the optimal stock of products. The results of the calculations are shown in Table 7.

Table 7: Calculation of inventory savings for Decada LLC

Inventory group	Cumulative equations	Actual inventory, units	Optimal Inventory, units	Inventory savings per month, units
Елітні годинники	y = 168,72ln(x) - 152,58	510	427	83
Аксесуари	y = 133,35ln(x) - 106,39	425	352	73
Набори	y = 81,943ln(x) - 65,3	263	216	47
Механічні годинники унісекс	y = 640,48ln(x) - 623,61	2023	1576	447
Смарт годинники жіночі	y = 401,56ln(x) - 307,45	1343	1072	271
Смарт годинники унісекс	y = 376,16ln(x) - 264,81	1197	1027	170
Механічні годинники жіночі	y = 385,4ln(x) - 406,08	1154	917	237
Автопідзавод жіночі	y = 492,97ln(x) - 482,34	1475	1211	264
Смарт годинники чоловічі	y = 370,78ln(x) - 372,58	1200	901	299
Кварцові годинники жіночі	y = 347,08ln(x) - 327,21	1062	865	197
Автопідзавод унісекс	y = 434,4ln(x) - 449,59	1332	1042	290
Прикраси	y = 74,348ln(x) - 62,179	234	193	41
Кварцові годинники чоловічі	y = 378,41ln(x) - 366,98	1184	932	252
Механічні годинники чоловічі	y = 359,21ln(x) - 349,17	1121	884	237
Кварцові годинники унісекс	y = 240,22ln(x) - 212,08	743	613	130

Let's determine the amount of savings using the statistical method. The cost of storing one watch per year (H): 60 UAH; cost of one order (S) 400 UAH; optimal order size: 400 watches.
In total, the need for savings per month = 3010 units.
Monthly cost of storing 1 item = 60 UAH.
Number of times orders need to be reduced = 3010 / 400 = 8 (rounded).
Inventory savings per month = 400*8+3010*60 = 183,800 UAH.

Let's also calculate the savings on turnover and assets (if you don't divert funds to the purchase of inventory, you can use them for investments or invest them in a bank account with interest). To calculate the relative savings, let's use the cost of the asset - 11% per annum and the cost of deposit interest - 16% per annum.

The funds in the monthly savings of 45,820,616 will be valued as an investment asset, the price of the asset will be 11% per annum and the cost of deposit interest will be 16%.

The amount of monthly benefit from the diversion of funds is: Cash as investment = 45,820,616 * 0.11 : 12 = UAH 420,022.

Money on deposit (simple interest accrual) = 45,820,616*0.16 : 12 = UAH 610,942.

The monthly benefit from the diversion of funds will be in the range of UAH 420,022 to UAH 610,942.

We also have savings on inventory in the amount of UAH 183,800.

5. Conclusion

To compare the most efficient method of inventory optimisation, let's compare the results of the calculations in Table 8.

Table 8: Comparison of the results of the study of inventories of Decada LLC by the ABC-XYZ analysis method and the statistical analysis method

Inventory group	Statistical analysis		ABC-XYZ analysis
Luxury watches	Savings of up to	16,28%	Increase by 10%
Accessories	Savings of up to	17,19%	Increase by 10%
Sets	Savings of up to	17,89%	Do not change
Mechanical watches unisex	Savings of up to	22,09%	Savings of up to 40%
Smart watches unisex	Savings of up to	20,18%	Savings of up to 20%
Women's Smart Watches	Savings of up to	14,21%	Savings of up to 20%
Women's Mechanical Watches	Savings of up to	20,53%	Savings of up to 30%
Women's Automatic Watches	Savings of up to	17,90%	Savings of up to 40%
Men's Smart Watches	Savings of up to	24,92%	Savings of up to 20%
Women's Quartz Watches	Savings of up to	18,56%	Savings of up to 20%
Unisex Automatic Watches	Savings of up to	21,78%	Savings of up to 20%
Jewelry	Savings of up to	17,50%	Do not change
Men's Quartz Watches	Savings of up to	21,28%	Increase by 10%
Men's Mechanical Watches	Savings of up to	21,14%	Savings of up to 20%
Unisex Quartz Watches	Savings of up to	17,50%	Increase by 10%
Men's Automatic Watches	Savings of up to	1,80%	Savings of up to 20%

According to the ABC-XYZ analysis, the fluctuations in savings are greater. Such categories as luxury watches, accessories, men's quartz watches, unisex quartz watches are proposed to increase in volume by 10%, while other categories, on the contrary, are proposed to decrease more, for example, unisex mechanical watches, women's self-winding watches.

For other categories of inventory, the proposal to reduce inventory is approximately the same - about 20%. These are inventories in the following categories: smart watches for women; smart watches for men; quartz watches for women; unisex self-winding watches; mechanical watches for men.

The unisex smartwatch category has a slightly larger variance, with 14 to 20% variation in savings possible. Men's self-winding watches do not need to be significantly reduced.

The average amount of savings due to inventory reduction using the statistical method is greater than the savings calculated by the XYZ method.

In addition, the statistical method is fully analytical and does not depend on the preferences of the researcher, as is the case with the XYZ method. Therefore, it can be concluded that the statistical method of saving finished goods inventory should be used more often than the XYZ method.

6. References

1. Ramanathan R. ABC-XYZ analysis for inventory management: a review and comparative analysis. Oper Res Soc. 2014;65(3):396-404. doi:10.1057/ors.2013.90
2. Montgomery DC, Peck EA, Vining GG. Introduction to Linear Regression Analysis. 5th ed. Hoboken: Wiley; 2012.
3. Scheer AW. ARIS – Business Process Modeling. 3rd ed. Berlin: Springer; 2000.
4. Silver EA, Pyke DF, Thomas DJ. Inventory and Production Management in Supply Chains. 4th ed. Boca Raton: CRC Press; 2016